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THE

PHILOSOPHICAL REVIEW.

MECHANISM, FROM THE STANDPOINT OF PHYSICAL SCIENCE.[1]

THROUGHOUT the modern period science has, upon the whole, moved toward mechanistic interpretations, theories, and conceptions of the forms and functions of living things. Even in the seventeenth century Harvey's great work, the reflections of Galileo and Descartes, and such applications of the new science as Borelli's, brought forth a mechanical physiology. At the end of the eighteenth century Lavoisier, and a little later Saussure, found the true path of chemical physiology; while Lavoisier and Laplace in collaboration founded thermal physiology.

During the nineteenth century every department of physical science has been tested and found useful in the study of organic phenomena, and at length we have won a certain measure of success in describing 'living matter' as a physico-chemical system.

Meantime this movement, though often checked by great and possibly insuperable obstacles, has never been reversed. The facts about living things, so far as relevant to physical science, whenever they can be brought into relation with the facts and theories of physical science, have always been found consistent with physical science. Such at least is the opinion of the overwhelming majority of qualified judges.

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[1] The papers which appear as articles in this number of the Review form the contributions of the five leaders to the Discussion which has been arranged for the next meeting of the American Philosophical Association, to be held at Harvard University on December 27 and 28, 1918. The papers as here published have grown out of a preliminary meeting and conference of the writers. At this meeting a "Basis of Reference" was drawn up to serve as a common background for the separate papers. This has been already published in the *Journal of Philosophy, Psychology, and Scientific Methods,* Vol. XV, No. 17 (Aug. 15, 1918), and is reprinted among the 'Notes' at the end of this number.—ED.

But this is not the whole story. Both form and function of the organism possess a pattern, and patterns are not often studied by the physical sciences, or at any rate by the abstract physical sciences which we are in the habit of thinking the foundation of orthodox mechanistic philosophy. It is true that Kepler proved that the solar system has a pattern, that Newton explained this as a special case of something which depends upon simple mechanical principles, and that later astromoners have found other examples which obey the same laws. It is true that there is no reason to suppose that all other patterns in space and time may not be explained in like manner. But yet it is certain that the pattern of organization has not been thus explained. The best available explanation of the pattern of organization is natural selection. But natural selection is at present not stated in mechanistic terms, and, until the logical aspects of this question have been more carefully examined, it must remain doubtful what is to be said about the place of the struggle for existence and the survival of the fittest as physico-chemical processes. Moreover, the measure of the importance of natural selection in organic evolution is in doubt.

Thus the fact of organization remains a cause of both bewilderment and uncertainty among those who study the philosophy and theory of biology. Sometimes this difficulty is magnified because successful investigators remain oblivious to the problem itself; for it is not necessary even to face such questions when working experimentally upon particular questions of biological physics or biological chemistry, and what is unnecessary in successful work may be forgotten in the analysis upon which a synthesis depends. Moreover, the general views of men of science are likely to be naïve because they are sometimes merely the reflections of trustworthy habits of work. This was especially true during the last quarter of last century.

It is for such reasons as these that the controversy between mechanists and vitalists has lately been restricted to the field of organization, and here, disregarding questions of psychology which I do not feel competent to discuss, I shall examine it.

In the first place it should be noted that two anti-mechanistic theories are at present in the field. The one, as held by J. S. Haldane, insists upon the phenomenon of organization as something which belongs to a higher level than physical science, which involves categories that do not belong to physical science, and which in some way annihilates the physico-chemical description upon which, nevertheless, it seems to rest. At certain points this theory is related to the opinions of Claude Bernard and of still earlier French biologists.

The other theory is vitalism proper, and may be represented by the views of H. Driesch. According to Driesch the activities of the organism often involve, at critical moments, the operation of a directing agent or entelechy which is above the physical forces in that it is able, for instance, to suspend the operation of the second law of thermodynamics.

Taking up first the neo-vitalism of Driesch and his allies, I know of no answer that can be made to it but one: The proof that mechanism is not enough to describe and explain certain organic phenomena, such as that which has been set forth by Driesch himself, is not of the character of scientific proof. In the very nature of the case it concerns phenomena which are but little understood, and accordingly it never seems to come to grips with the question. Try as I may, I have not been able to see in Driesch's proof of vitalism more than an interesting and valuable, but overconfident, discussion of obscure subjects.

It is customary to oppose Driesch's arguments with the induction in favor of the second law or the other most general principles of physics, and it is truly said that nearly the whole of physical science contributes to the induction. Nearly, indeed, but not quite the whole. For there still remain uncertainties about the second law which were known to such men as Willard Gibbs, Clerk Maxwell, and Boltzmann; and, as a rule, the best physicists are rather more cautious about claims of exhaustive and rigorous proof than are either mechanists or vitalists among the biologists.

Clerk Maxwell long ago pointed out another difficulty which confronts those who try to meet Driesch specifically. There is an important class of physical phenomena which are habitually avoided by the physicists, and which involve great difficulties for the determinist. These include processes which possess singularities of many kinds, such as the right word at the right time, or, turning to physical phenomena, certain types of catalytic processes. Similar ideas have been presented by Boussinesq and by Charles Peirce. Now it is upon phenomena such as these, doubly obscure because hidden within the living cell, that Driesch founds his case. His opponent is therefore somewhat put to it to stretch the induction of the second law so as to include these critical cases. Most of us feel confident that the second law will hold, but if we claim too much we shall be putting opinion in place of certainty, just as we think Driesch does. And so, for my part, I can only come back to the conviction that Driesch is talking too confidently about things that none of us understand, and that, so far as I can judge, the weight of the evidence is greatly against him. For the well known types of physical phenomena this seems to be established. There is room for a difference of opinion only in certain obscure cases. But there can be no doubt, as Clerk Maxwell long ago said, that such cases are of peculiar importance in the organic world.

The anti-mechanistic opinions of Haldane are of quite a different character. For Driesch the miracle of organization is such that it can exist only by virtue of certain agencies which do not belong to the world of physics and chemistry. For Haldane, who is a thorough-going idealistic metaphysician when not experimenting in the laboratory, physics and chemistry are but imperfect stepping stones to knowledge, and cannot be in question when the miracle of organization is before our eyes. This opinion of an eminent experimental physiologist has proved disconcerting to some of his colleagues, and has been generally misunderstood.

In the first place, as Haldane says, it is not the physical and chemical phenomena, but the organization of them, with which the biologist, as such, is concerned. He must indeed know the physical and chemical phenomena so as to be able to see their organization. But it is this pattern of organization which is the really biological phenomenon. In short, a knowledge of the pattern of organization of chemical and physical phenomena in space and time leads us on to reality. And then, if I too have not misunderstood Haldane's view, somehow we have only the pattern; time, space, molecules and calories have disappeared.

I can only leave the metaphysical portion of this doctrine to the metaphysicians. For the rest, it seems to me plain that organization is a necessary biological category, that it is not involved in abstract physical science, and that mechanism (as now understood) leaves it out.

If this is true, two questions arise. The first is whether a straightforward description of organization should be regarded as a mechanistic description. Here, as I believe, we are concerned only with a matter of definition, complicated by the fact that physiologists have not yet made great progress in the study of organization, as distinguished from the phenomena which are organized. But, in spite of Haldane's conviction that it is impossible to conceive organization in physical and chemical terms, this seems by no means impossible to most physiologists, and many are plainly making progress in this direction.

Moreover, all the characteristics of the organization of living things are not peculiar to such organisms. Thus it is generally admitted that to speak of the organization of society is more than a figure of speech, and the justification of this view is found in the similarity of regulatory processes and of the conditions of stability in the two instances. It is true that each type of organization has its distinctive characteristics, but in large measure these depend upon the nature of the materials organized.

Another example of organization, no less conspicuous when closely examined, is the meteorological cycle. Here again it is the regulatory processes and the conditions of stability which reveal the true nature of the case.

In short, organization, while peculiarly a biological category, is by no means restricted to the field of biology. It is not, to be sure, involved in the abstract physical sciences, but whenever particular systems are in question, in meteorology and in sociology as well as in biology, organization is in question. Indeed I can see no objection to speaking of the organization of the solar system. The idea behind these views is as old as Lucretius.

Accordingly, it seems not unreasonable to hold the opinion that the fact of organization is insufficient to overthrow the mechanistic hypothesis, although it must be admitted that a mechanistic philosophy which leaves organization out is meaningless. For the world is made up of nothing but individual systems, in which we find matter and energy, and sometimes organization.

Finally, Haldane's analysis naturally leads to another question. What is the origin of organization? Is it natural selection, or speaking more generally so as to include the thought of Hume and of Lucretius, is it the fact that stable systems survive, and that some kinds of stability involve that which, in the organism, we call regulatory processes?

I cannot answer this question, and I am suspicious of all attempts to answer it. For no one knows whether life has always existed in the universe, or, if not, by what process it first appeared.

Admitting the alternative more favorable to vitalism, we may say that conceivably the pattern of the living organism is not merely the result of a mechanistic process, but that the primitive elements of it may have always existed. This would distinguish it from the organization of the meteorological cycle or of society, and seriously undermine the mechanistic hypothesis.

But, because I seem to see a pattern in the properties of the chemical elements which is, so to speak, predetermined rather than a product of adaptation, and because this pattern involves the very difficulties which are raised by the hypothesis that life has always existed, this last objection falls away.

Therefore, with the qualification that science is far from omniscient, and the reservation that I cannot pretend to judge the problems of psychology, I accept the mechanistic hypothesis as, upon the whole, most consistent with the evidence.

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